

Study on MT Gear Shifting Behavior

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Abstract---This paper introduces a test-bed of gear shifting behavior on manual transmission. It is used to test the shift force and displacement of shifter. This experiment data can be used to evaluate the shift feeling of manual transmission. Usually, we evaluate the shift feeling subjectively. The test-bed can work automatically, which can avoid the subject factors of shifting by human. In the end of this paper, experiment data is gave to prove the validity of this test-bed.

Key words---Testing Beach; Manual transmission; Shift;Analysis

I The development background of the testing beach

The manual transmission still holds a large share in the current market at present [1]. And the transmission needs bench test in our country. However, at present, only larger transmission factories have professional transmission test beach, and these test beaches mainly rely on import, which caused that the manual transmission development cycle has been becoming slowly and made transmission manufacturer product modifications without a fixed standard. Therefore, based on vehicle maintenance detection markets, automotive engineering college of Wuhan University of Technology developed a set of transmission testing beach, which could solve the problem of manual transmission performance test.

II The overall design of manual transmission test beach

A. The mechanical design of the testing beach

The design of test-bed is the key of the whole hardware system design. Figure 1 is the layout diagram of the test-bed.1---Phase asynchronous motor ,which is one of the main moving parts of the whole experiment stage, is mainly used to simulate the engine speed when shifting, using the PCI --- 1711 DAQ analog output port(AO)conducts the speed control of the engine. 7---a shift stepping motor is

the power source of the shift manipulation mechanisms. Fix a stepping motor in choosing direction and shifting direction respectively, which could complete the shift according to certain angle.12--- Inertia group(to simulate kinetic energy) and 13---eddy current(to simulate the resistance)are the load equipment for the testing beach.5--- Speed torque sensor and 8--- shift force sensor mainly complete to collect real-time data, which could provide an objective basis for the following data analysis.

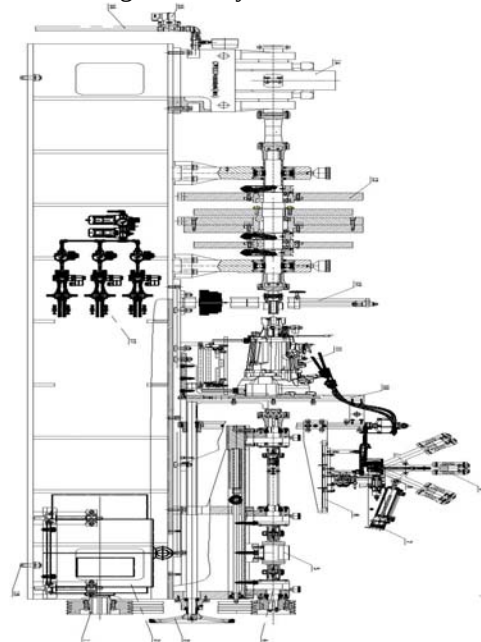


Figure 1. The layout diagram of the test-bed

1- Phase asynchronous motor 2- Test base 3- adjusting handle 4- Pulley bearings 5- Speed torque sensor 6- Operation base 7- Shift stepping motor 8- Shift force sensor 9- Transmission fixed fixture 10- Transmission 11-weighting holder 12- Inertia dish group 13- Eddy current 14- The eddy current inlet valve relays 15-

Feed electricity eddy 16- Pneumatic pipe 17- Test base adjustment screws

Industrial computer, printer, and graphical display device are fixed on test beach console, which mainly completes the experimental operation of control and result display. The main function of the power distribution cabinet is to supply the power to the testing beach. Use relevant sensors to gather the data in this test system.

TABLE 1. Main Measurement Instrument

Name	Model
Choose gear force sensor	BK - 5B cantilever type sensors
Shift force sensor	BK - 5D cantilever type sensors
Angle sensor	CK series Angle sensor
Torque sensor	JN338A dynamic speed torque sensor
Eddy current dynamometer	GWD series disc eddy current dynamometer
Clutch displacement sensor	WG - 100 inductors FM type displacement sensor
Clutch torque sensor	AKC - 17B static torque sensor

B The software designing of the testing beach

The industrial personal computer (YanhuaIPC-510-4U) uses the testing software to complete data and parameter setting, graphical display, data management and other functions. The testing software is composed of main interface, digital display interface, real-time curves interface, test reports interface and statements management interface.

The control software is composed of login module, data acquisition module, motion control module, graphic display module and data management module.

(a)Data acquisition module

Data collection port (for the testing beach): 32 DI.

Data acquisition board(for the testing beach):Yanhua PCI-1711

(b) Motion control module

Choose 57000 series Size 23 linear stepping motor ,Haidun DCM 8028 type stepper motor drivers and PCL-839+motion control card for the testing beach.

(c) The data acquisition of this procedure is realized by

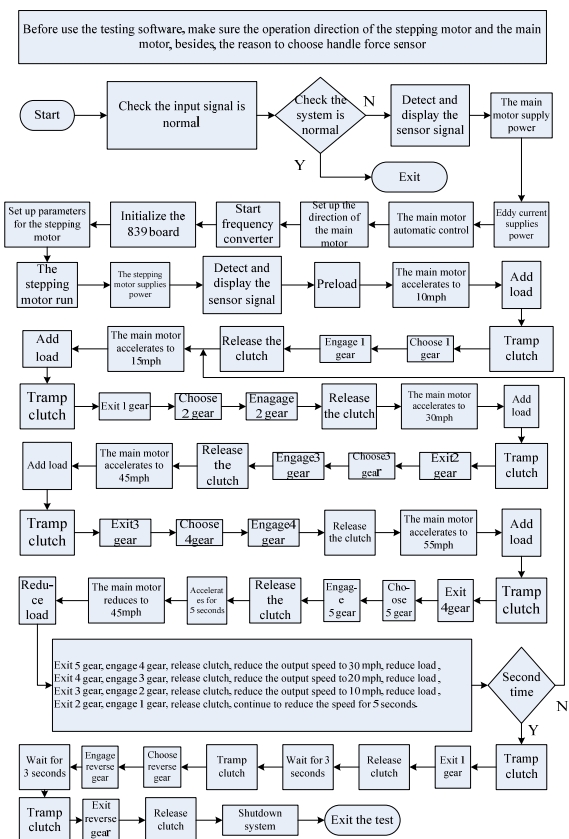


Figure 2. The test-bed detection flow chart

Continues to collect data. And it will input the data collected to queue. The main program ,while cycle, uses a queue function to read VI to collect data, and extracted the data which is required . When the collection is over, put the data extracted into the array and it will get into the next state. The sampling data was put two local variables. Through the shift register, we can replace the subset which is used to display graph. Each graphic display points were refresh through each cycle, we could get a succession of curve in Graphics display window. The dimensional array will be saved to TXT files, which can offer help for later data processing.

(d)Data management module

With the help of the tool bag LabSQL (LABVIEW),we can realize data operation. The step for writing operation to the data base as follows:

The first step: Use ADO Create.vi to create connection object, then use ADO Connection Open.vi to establish connection with the database.

The second step: Use ADO Record set Create.vi to create a Record set object, then use ADO Record set Open.vi to open it, at the same time use SQL to write orders to get the record from the database.

The third step: Use ADO Record set Close.vi and ADO Connection Close.vi to close the connection of the database,

meanwhile add error output.

The query and delete operation of the database steps as follows:

The first step: as mentioned above, connecting data sources;
The second step: Use ADO Record set Create.vi to create a Record set object, then use ADO Record set Open.vi to open it, at the same time use SQL query command to get the record from the database.

The third step: Choose the function button (such as: inquiry, delete, clear the database). The use ADO Record set Close.vi and ADO Connection Close.vi to close the connection of the database.

III Shift experiment and data analysis

A Experimental parameters

The experiment is mainly to do the progress of shifting from one gear to two gear.

TABLE 2. SC63 Transmission Choose File Angle

Choose gear	Angle/°	Force protection value/N	Angle protection value /°
1,2	12.7	120	14.7
3,4	0	120	-1---1
5,R	-13.9	120	-15.9

Note: 1, 2 are defined as are angle, choose 5, R are negative.

TABLE 3. SC63 Transmission Shift File Angle

Shifting gear	Angle/°	Force protection value/N	Angle protection value /°
1	20	60	22
2	-17	60	-19
3	15	60	17
4	-16.5	60	-18.5
5	19	60	21
R	-19	60	-21

Note: 1, 3, 5 are defined as are angle, choose 2, 4, R are negative.

TABLE 4. The conversion relation of N109 mini-typed vehicle speed to motor speed

Gears	Shifting speed/km/h	The output speed of Transmission/r/min	The input speed of Transmission/r/min	Motor speed/r/min
Pre speed	17	658	658	446
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1-2	25	967	3647	2472
2-3	50	1935	3706	2512
3-4	70	2709	3628	2459
4-5	90	3483	3483	2361

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5-4	70	2709	2189	1484
4-3	50	1935	1935	1312
3-2	30	1161	2223	1507
2-1	15	580	2188	1483
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-R	17	658	658	446

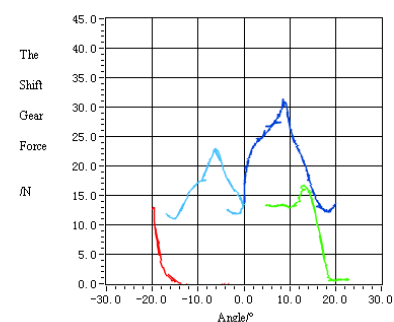
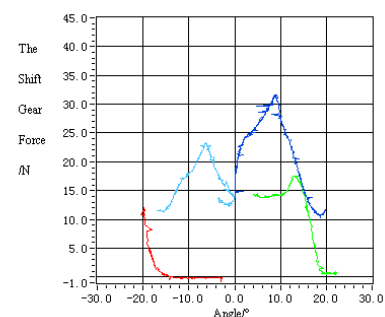
Note: wheel radius: 0.268 m Lord deceleration ratio: 3.909
transmission input speed = motor speed * 1.475

B Shifting experiment

The steps :

- (1) Check the testing beach and make some relative works;
- (2) Make sure the shift engagement in the state of zero;
- (3) Run relative experiment produces and begin to test;
- (4) The shift engagement is forced to make one gear at the speed;
- (5) Accelerate the output speed of the motor to 720r/min;
- (6) The clutch is separated;
- (7) The gearbox back to one gear;
- (8) Adjust input speed to 2000r/min;
- (9) The gearbox is engaged with two gear;
- (10) Switch the clutch;
- (11) Accelerate properly;
- (12) After that, the testing beach is back to default position, then the shift test experiments ends.

Among the above steps, the seven step and the nine step are main testing programs during the experiment. The followings are test data on the basis of experiment requests:



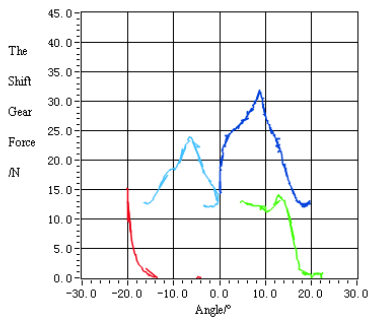
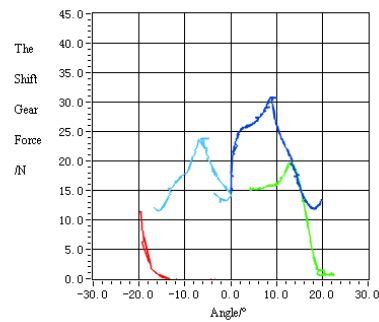


Figure3 1 files in second gear test

Note: the blue line: hang 1 files; Green line: retreated 1 files; Shallow blue: hang 2 files; Red line: back 2 files

C Contrast analysis conclusion

When the test is over, the test data is needed to select and adjust properly, then analysis it.

The first experiment: shifting one gear to two gear (back to one gear testing)

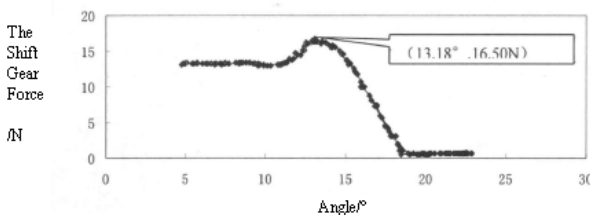
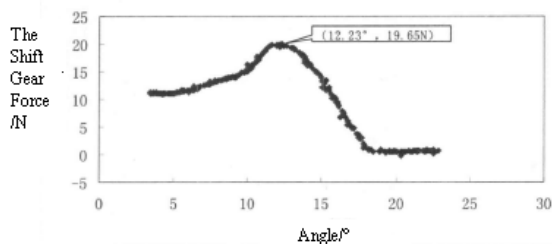


Figure 4 Retreated 1 gear experiment

The second experiment: shifting one gear to two gear (move to two gear)

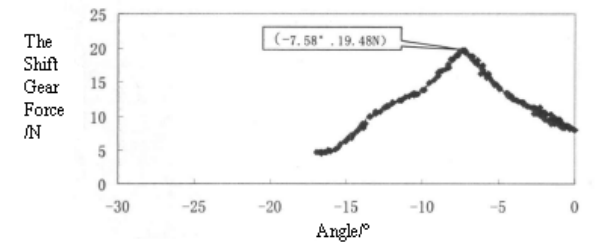
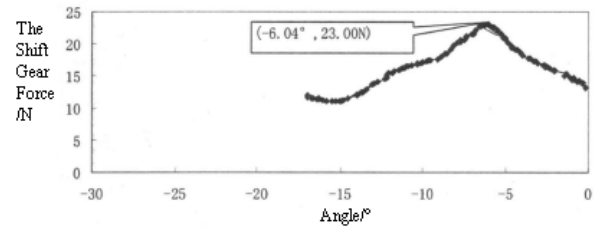


Figure 5 Hang second gear experiment

The conclusions:

- (1) Back to one gear: the max shifting force is about 17.88N and corresponding position (the angle with the shifting rod) is 12.86° ; During the progress of shifting two gear, the force is about 10.7N and corresponding position (the angle with the shifting rod) is 6.66° .
- (2) Shift to two gear: during the progress of shifting, the shifting force trend is up firstly and then down, the curve of force has obvious peak value.
- (3) Shifting force increases very slowly before the peak value is arrived, the curve trend is very gentle, once reach the peak value, the shifting force is declined rapidly, the rate of curve slopes becomes larger significantly.

IV The conclusion

Today, the theoretical analysis and data analysis about the manual transmission experimental is relative deficiency. With limited project time and conditions, there has not taken test about a lot of the same model and different models of manual transmission. So, the conclusions authenticity of the experiment need to further study. Currently, there only has finished the first step that automatic shifting problems and data collection issues, and the test bed cannot test the manual transmission synchronizer's synchronization time. Therefore, the transformation of the test stand and how to solve the problem of data collection is a top priority for future research.

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